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HARMONIC ATTENUATION

In the following article, the causes of the radiation of harmonic frequencies from a transmitter in addition to the required fundamental are described, and the result of such radiation, and means of practically eliminating all frequencies other than that desired, are discussed.

It is shown that filter circuits between the output of the transmitter and the aerial, and suitable precautions taken in the design of the transmitter itself, go far to avoid any disturbing radiation of harmonics.

ALTHOUGH the thermionic triode is without question the most effective instrument yet available for the purposes of generating and amplifying high frequency oscillations, nevertheless there are certain disadvantages noticeable in its practical applications which result in a marked departure from the ideal performance of a perfect device. Of these disadvantages, probably the most serious in effect, and the most difficult to counteract, is the tendency of the valve to produce not only the required fundamental frequency, but a series of partials or harmonics, varying in their amplitude ratio to the fundamental according to the particular adjustments of the valve and the character of its associated circuits, but always present in a more or less disturbing degree in every installation operated at reasonable efficiency.

The production of these undesired frequencies is normally due to a combination of causes. In the first place, the characteristic curves of the valve are not linear throughout their full extent. Secondly, in the interests of efficiency, amongst other reasons, it is essential to adjust the operating point of the valve in such a manner that at most only one half of the grid swing is effective in varying the anode current. Other causes which may act detrimentally to the production or reproduction of a pure wave form are the variation in amplitude of the grid current during a cycle, and the damping effect of the load on the oscillatory current in the output circuit of the valve.

The net result of these various phenomena is that even if a sine voltage is applied to the grid the oscillation produced in the output circuit is distorted, and this distorted wave form is resolvable into a fundamental frequency and a series of harmonics.

If these harmonics are permitted to be radiated from a transmitter, it is clear that the particular station is not only occupying its allocated position in the wave band, but is to all intents and purposes a multi-wave transmitter with possibilities of disastrous interference with numerous other lines of communication.

The greater the power of the transmitter, other things being equal, the greater will be the power and interfering range of the harmonics, and consequently the greater the necessity for precautions against such radiation.

The problem is of the first importance in connection with every transmitter of any power working above about twenty metres, and until an adequate solution is found, and, in addition, universally applied, carefully considered allocations of wave lengths to particular stations and classes of service, and elaborate arrangements for ensuring stabilisation of frequency will to a considerable extent be nullified and the full benefits of such organisation fail to be realised.

As matters are at present, lower harmonics of the long wave telegraph stations disturb broadcast listeners, second harmonics of broadcasters in the upper part of the band interfere with those lower in the wave scale, and all of these may badly jam short wave services of many kinds. In the short wave band itself, the radiation of harmonics can produce unexpected and far reaching effects, due to the fact that under certain conditions of time and season particular frequencies are transmitted with extremely small loss, so that even a very low power under these conditions will produce an operative signal at remarkable distances.

Cases are frequently recorded of a short wave transmitter several thousands of miles distant from the receiving point being clearly received on a harmonic at times when its fundamental has been completely inaudible. Such effects, although occasionally convenient, are obviously quite inappropriate to a well ordered scheme of frequency allocation.

Clearly, improvement on normal existing practice is called for, and the object of the present article is to call attention to certain possible remedial measures which are applicable, although, unfortunately, not all without additional expense and some degree of complication.

It is apparently impossible with any feasible arrangement of existing valve oscillators to prevent the generation of harmonics, and efforts therefore have to be confined to the prevention of their direct radiation, and to means for securing maximum attenuation before they reach the aerial.

Some idea of the numerical values to be expected in practice will assist in forming an appreciation of the problem involved.

As previously indicated, the strength of the radiated harmonics in comparison

with the fundamental, varies widely as between different types of transmitter. In the case of a telegraph transmitter of a very usual sort, the ratio of the field strength of the strongest harmonic, generally the second or double frequency wave, to the fundamental measured a few miles from the station, may be as high as $\frac{1}{100}$, while with a modern broadcast transmitter, this fraction may be as low as $\frac{1}{2000}$.

These figures, of course, correspond normally to very small amounts of energy. In the worst case mentioned the harmonic energy radiated is only $\frac{1}{10^4}$ of the fundamental, and in the latter example only $\frac{1}{4 \times 10^6}$.

Unfortunately, even such comparatively small powers are capable of causing considerable trouble in a sensitive receiver. A concrete example, based on field strength measurements taken at a distance of five miles from a certain broadcasting station of the most modern type, may be of interest. The particular transmitter operates with about thirty kilowatts carrier energy in the aerial, and incorporates a number of precautionary measures tending towards attenuation of the harmonics. In this case the field strength of the fundamental at the distance mentioned was found to be approximately 300 millivolts per metre, while the second harmonic was about 150 microvolts, say a ratio of $\frac{1}{2000}$, or an energy of $\frac{1}{4 \times 10^6}$ of the fundamental. In the particular example, this would mean that the power of the strongest harmonic is of the order of one hundredth of a watt, which might appear to be a negligible quantity.

The field strength of 150 microvolts produced at five miles would, however, be far from negligible if attempts were being made to receive a distant transmission of the same wavelength as the harmonic, but to appreciably reduce the already minute harmonic energy radiated is obviously a problem of some magnitude.

There are certain possible features in the design of a valve transmitter, incorporation of which will prevent the harmonic radiation reaching a strength it might otherwise attain, and amongst these precautions the following are worth noting.

The oscillatory circuit of the valve should either be so proportioned that the correct alternating anode volts are secured with the anode tap connected directly to the tuning condenser, as in Fig. 1, or if such a ratio of inductance and capacity is not feasible, then the tuning condenser should preferably be arranged with units in series, and the anode tapped down the condenser, as in Fig. 2, rather than be tapped down the inductance, as Fig. 3.

In the coupling of valve circuits in cascade, or in the coupling of a valve circuit to an aerial, there is a useful advantage obtainable by utilising a condenser as the coupling member in place of an inductance. This advantage becomes very marked as regards the higher harmonics, seeing that the harmonic voltage produced across a condenser, as compared with the voltage drop across an inductance of equal impedance to the fundamental, is in the ratio of $\frac{1}{n^2}$, where n represents the number of the harmonic.

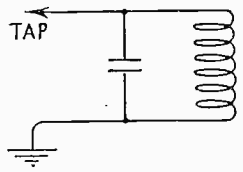

FIG. 1.

It is desirable again to connect the coupling member in the inductive branch of an oscillatory circuit rather than in the capacity branch, for example, an inductive coupling should be arranged as in Fig. 4, and not as in Fig. 5, and a capacity coupling as in Fig. 6, in preference to Fig. 7.

From the point of view under discussion, the negative grid bias applied to the valve should be a minimum, as a heavy grid bias results in short flicks of anode current producing a wave form in which harmonics are very pronounced. In this respect the most favourable type of transmitter in normal use is that used widely for broadcasting purposes, wherein the high power stages amplify modulated oscillations, and in which in the interests of linear reproduction, it is essential that the complete positive half cycle of the grid input voltage is effective in varying the anode current, notwithstanding the reduction in efficiency which such a method involves. This is an important advantage possessed by the low power modulation system over the alternative full power modulation method, in which, in order to secure a reasonable overall efficiency, it is imperative to operate the high frequency amplifier on the "flick" method with the consequent high harmonic production. Theoretically, some alleviation of the harmonic trouble is obtainable by arranging the valves in the so-called "push-pull" connection, which should result in a balancing out of the even harmonics, but exactly how effective this is in practice, particularly on high power sets where a number of valves are concerned, is somewhat doubtful. A point in design which may reduce direct radiation in some degree, is to construct the tuning inductance of the oscillatory circuit in the form of an astatic pair.

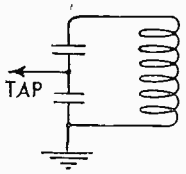

FIG. 2.

A factor in the adjustment of a transmitter which can exercise a marked effect on the distortion of the wave form is the degree of coupling between the output circuit and the load.

If the damping imposed by the load is too great, or if in other words the ratio of the output circuit volt amperes to the load circuit watts is too small, there will,

with the normal single circuit, be a marked difference in amplitude between the half cycle during which energy is being fed to the circuit and the half cycle when energy is only being abstracted from the circuit. This difficulty can be overcome by adopting the " push-pull " arrangement, and so allowing the valves to provide energy each half cycle.

Another favourable feature in the design of a station is the locating of the aerial and its tuning components at a distance from the transmitter, and the provision of a feeder or transmission line for linking purposes. By this means the aerial is less likely to be influenced directly by harmonics existing in the valve circuits, and with suitable coupling devices a useful reduction of harmonic radiation is possible. The adoption of such a feeder lends itself conveniently to the inclusion of harmonic " traps " tuned to the undesired frequencies, these " traps " taking the form either of rejector circuits placed in series in the feeder leads, or of acceptors connected from the feeder leads to earth. Where it is desired to attenuate some particular harmonic, particularly one of a high order, such " traps " have useful possibilities, but, so far as the writer's experience goes, where the second harmonic is concerned the improvement resulting is not normally sufficient to meet modern requirements.

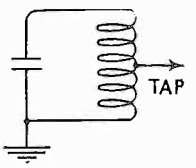

FIG. 3.

Similar tuned " traps " have, in some cases, given favourable results when inserted in various positions in the valve circuits themselves, but where such attempts are made, care should be taken to effectively screen the " trap," or the effects of direct induction on neighbouring circuits may make the trouble even worse than originally.

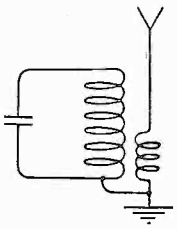

FIG. 4.

Even with all the palliatives enumerated above incorporated in a valve transmitter, it is unhappily a fact that in most cases the strength of the harmonic radiation will still be sufficient to cause troublesome interference on wavelengths where ideally such interference should be non-existent, and we are forced, therefore, to seek for further and more definite safeguards.

Probably the most effective means for obtaining the desired degree of immunity is the insertion of a suitably designed wave filter between the output circuit of the transmitter and the aerial. It would seem that credit for first utilising this useful device in connection with radio transmitters should be accorded to the Marconi Company, inasmuch as that Company initiated experiments on such lines at Chelmsford and Ongar as long ago as 1922, when it was shown that a low pass filter could produce a considerable harmonic attenuation without appreciably affecting the efficiency of the transmitter on its fundamental frequency. This development was probably some-

what in advance of its time at the date mentioned, and no commercial use was made of it until more recently, when the problem of harmonic interference was brought into particular prominence, due to the advent of broadcasting, with its resultants of numerous transmitters, many of considerable power, and an enormous number of private receiving stations.

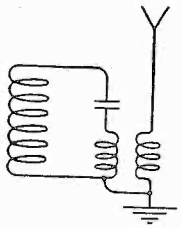

FIG. 5.

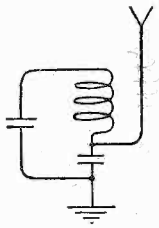

FIG. 6.

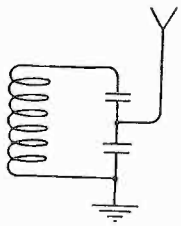

FIG. 7.

The filters normally used have been three stage low pass of T section, with the components mounted in screening cases constructed in sections shielding one stage from another.

Fig. 8 represents a diagram of such a filter with one possible arrangement of coupling to the valve output circuit and to the aerial.

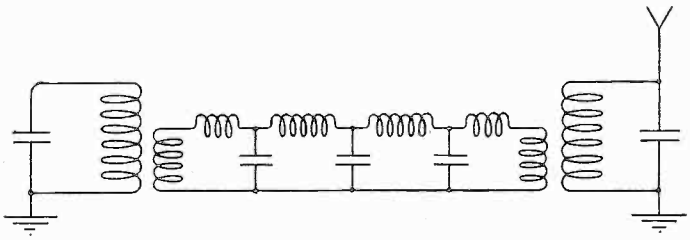

FIG. 8.

The filter, naturally, will only operate effectively in conjunction with a certain terminal impedance for which it is designed, and if a feeder line is to be included it is also essential that this should possess the same surge impedance. For medium wave transmitters using open feeders an impedance of about 600 ohms has been found convenient, and the apparatus is usually designed to meet such conditions.

A filter of the type mentioned above will theoretically produce an amplitude attenuation in the cut off region of some 48 T.U., so if properly used such a filter may be expected to attenuate the harmonics to at least $\frac{1}{100}$ of their original amplitude, and this degree of attenuation should be sufficient, provided the transmitter has been

intelligently situated in regard to centres of population, to give a satisfactory immunity from disturbances in the majority of cases. Of course if essential, as far as the filter itself is concerned, this can be made still more selective by increasing the number of stages.

A factor not always realised, but nevertheless of primary importance in relation to the practical effectiveness of any form of harmonic attenuator is the degree of screening provided against direct radiation from the valve circuits, more particularly of course in the high power stages of a cascaded transmitter.

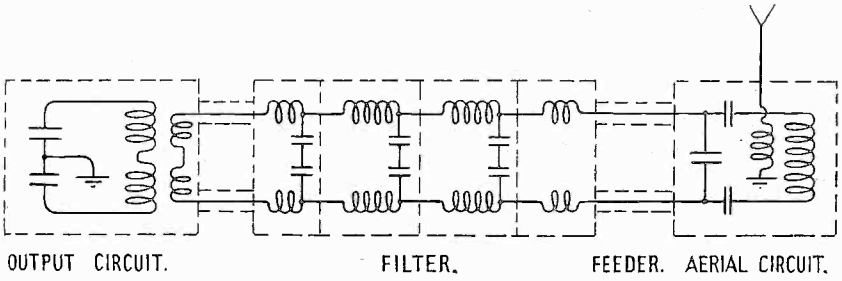

FIG. 9.

It has frequently been observed, when making measurements of harmonic field strength at short ranges from a transmitter that the disconnection of the aerial from the set, other circuits being maintained under equal conditions, has produced no appreciable reduction of harmonic strength. Quite obviously in such cases the insertion of a harmonic attenuator between the output circuit and the aerial is perfectly useless.

Not only should the transmitter circuits and the attenuator be effectively shielded but also the leads connecting the transmitter to the attenuator, otherwise harmonic fields will, as it is termed, " jump " the attenuator, and induce voltages on the wires leading out from the attenuator and thence influence the aerial.

The ideal arrangement, therefore, would be as outlined in Fig. 9 in which the dotted lines represent the earthed metal shielding cases.

The diagram represents an arrangement suitable for working with a " push-pull " output circuit, a very desirable method when a feeder line is included in the set, as it is then easy to arrange for each of the feeder wires being at the same potential above earth, which tends to facilitate securing correct adjustments.

Unfortunately it is a very difficult matter effectively to screen a large transmitter in a practical manner. Various supply leads and water pipes have to be led into the valve enclosures and numerous indicating instruments must be arranged visibly, all of which make it almost essential to provide several apertures in the screening cases.

Probably an effective scheme would be, in addition to individual screening of the different valve stages, to instal the transmitter in a metal building, or in a brick building lined with metal, with the screened harmonic attenuator placed either externally or in a separate compartment inside the building, the input leads as previously recommended being run in shielding trunks.

Another possibility would be to place the transmitter below the ground. level, and to cover the crypt or basement with a metal roof, which might form the floor of an upper storey housing control rooms, machinery, hall and offices. Such an arrangement could most probably be made remarkably effective, and may well be an approved design for radio stations of the future.

Naturally none of these constructions can be incorporated without materially increasing the initial cost of the complete station, and for this reason, presumably, little has been done on such lines up to the present.

It is the writer's opinion, however, that before long innovations on the lines indicated will have to be introduced by those bodies responsible for the operation of radio services, and it is not unlikely that international regulations will force the issue and make it imperative for all concerned to utilise to the utmost every device known for minimising the existing harmonic nuisance.

W. T. DITCHAM.

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TONE MODULATION OF TELEGRAPHIC TRANSMITTERS

PART II.

The following article completes the discussion on the Tone Modulation of Telegraph Transmitters, which appeared in the July Issue of THE MARCONI REVIEW.

It is thought that the practical nature of the various points dealt with will be appreciated by those who are particularly interested in Marconi Transmitting Apparatus.

Tone Modulation applied to the Absorber Method of Keying Transmitters.

THE object of including an absorber in the general scheme of transmitter equipment is to ensure steady load conditions as between "mark" and "space," it is, in fact, the only satisfactory method of keying when speeds of over 100 w.p.m. are desired and is a feature of the high power Marconi-Franklin Beam Transmitter.

In order to obtain Tone Modulation of the standard transmitter there are two methods available, viz., supplying the set from a source of unsmoothed rectified A.C. and, secondly, keying the set at a sinusoidal tone-frequency, a method that is suitable when the supply is in the form of direct current. Dealing with the latter method first, Fig. 5 represents the scheme of keying a S.W. transmitter : it will be understood that with "key open" there is sufficient negative bias on the grid of the sub-absorber valve to render the latter non-conductive : this condition implies a comparatively high potential at the sub-absorber anode, which is applied, at a suitably reduced value via the floating battery, to the grid of the main absorber, and renders it conductive. Again, owing to the drop across the main absorber resistance, this implies low potential at the main absorber anode and consequently insufficient energy to cause No. 2 amplifier to operate and drive No. 1 Power Amplifier. Conversely, with the key closed, the alternating potential already existing across R_L is now applied to the grid of the sub-absorber valve, rendering the latter alternatively conductive and non-conductive ; that is, its anode will experience an alternating change of potential. It follows that the final or Main Power Amplifier will be alternatively driven and not-driven, thus the output during "mark" will be a series of more or less sinusoidal periods of radiation, and in Fig. 6 an attempt is made to illustrate the theoretical variation of anode current for various degrees of sub-absorber grid bias and various degrees of swing (power) of the tone modulator. In the figure, (A) illustrates the effect on the Sub-Absorber Anode Feed, of varying the amplitude of A.C. potential applied to the grid, after the grid bias has been so adjusted that under static conditions the anode current is just cut off. Again (B) illustrates the effect, on Anode Feed, of varying the bias applied to the sub-absorber grid when the amplitude of grid A.C. potential remains constant. In practice the effect is decidedly differential, since the positive A.C. amplitude automatically

increases as the damping is reduced, that is, as the negative bias is increased. It will be observed that the dotted line indicates grid potential while the full line indicates anode current : note that the final output of radio waves from the antenna follows approximately the variations of the sub-absorber anode current and thus, in a way, the full line curve represents the theoretical variation in the final transmitter output.

Owing, however, to transient inductive effects the theoretical output is not realised in practice, and the actual output of the Main Power Amplifier is more than normally reduced when tone frequency variations are applied to the grid of the sub-absorber valve. In Fig. 7 the "trace" (a) is an actual oscillagraph of the

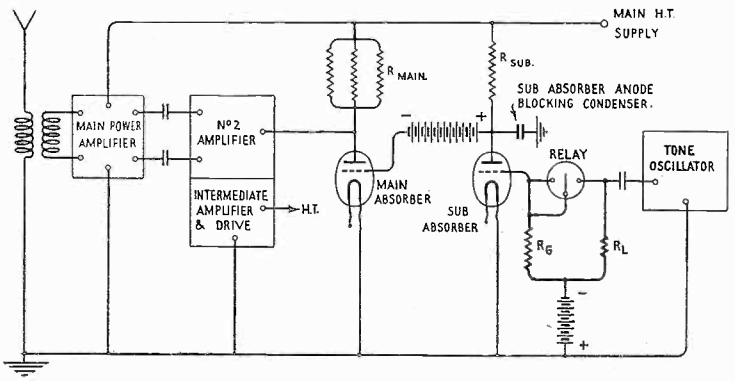


FIG. 5.

rectified output of a transmitter sending at the rate of 150 w.p.m. with a tone modulation of 500 cycles : taking the basis of emission for pure C.W. to be 100 per cent. it will be seen that the signals for tone modulation are only active for some 25 per cent. of the period. Now the writer has found that this effect may be controlled by the expedient of inserting a blocking or curbing condenser between earth and sub-absorber anode, below the anode resistance—see Fig. 5—and in Fig. 7 the traces (b), (c) and (d) illustrate the effect of 0·05 and 0.10 mfds. inserted in combination with three values of resistance. Clearly to obtain a given effect the capacity has to be chosen with reference to the value of resistance (see note) and to the tone frequency.

In passing, it may be mentioned that results obtained at the receiving stations have indicated that the curbing condenser "cleans up" the signals, that is, it tends to eliminate the higher harmonics and leads to very satisfactory reception.

Full Wave Rectification of Tone Oscillator.

Another method of overcoming the diminution of radio frequency power is to pass the tone oscillator output through a double electrode rectifier, before applying

it to the grid of the sub-absorber ; this method, however, possesses the following three minor disadvantages :—

(A) It is still preferable to apply a small amount of curbing, in order to filter out the higher harmonics.

(B) It involves another valve, with A.C. filament supply and transformers.

(C) The doubling of the tone frequency, as has been explained, is a retrograde step—of course the tone oscillator frequency can be halved, but this implies a very low frequency indeed.

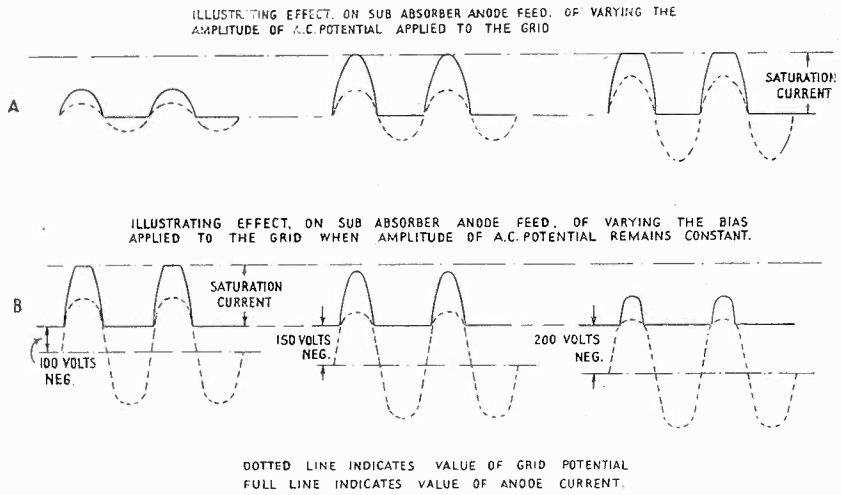

ILLUSTRATING EFFECT ON SUB ABSORBER ANODE FEED OF VARYING THE AMPLITUDE OF A.C. POTENTIAL APPLIED TO THE GRID
A
SATURATION CURRENT
ILLUSTRATING EFFECT ON SUB ABSORBER ANODE FEED OF VARYING THE BIAS APPLIED TO THE GRID WHEN AMPLITUDE OF A.C. POTENTIAL REMAINS CONSTANT.
B
SATURATION CURRENT
100 VOLTS NEG.
150 VOLTS NEG.
200 VOLTS NEG.
DOTTED LINE INDICATES VALUE OF GRID POTENTIAL
FULL LINE INDICATES VALUE OF ANODE CURRENT.

FIG. 6.

Note on Absorber Keying.

It not infrequently happens that, after some months running, complaints are received of " spacing waves " being sent out by the transmitter, despite the fact that all the oscillatory circuits have been carefully balanced and that the usual routine inspections and check adjustments have been properly carried out. The trouble, however, may be that of the main absorber valves gradually losing their pristine emission, and since the falling off in anode current has been slow, and in any case slight, *e.g.*, falling from 1·60 amps to 1·50 or 1·55 amps, the factor remains overlooked and yet may be sufficient to reduce the drop in potential across the main absorber resistance to an extent that increases appreciably the potential applied to No. 2 Amplifier Anodes. The effect of this is to drive No. 1 Main Amplifier, feebly perhaps, but still sufficiently to energise the circuit and cause the emission of low power waves, which, despite the absence of any indication on the feed ammeters, under good conditions reach the receiving station with sufficient strength to interfere with signal formation.

It will be found that adjusting the floating main absorber grid bias battery has very little effect on this condition at the Absorber Panel, and though increasing the brilliancy of the valve filaments may improve matters, the improvement is only temporary, and a costly one in respect of valve life. The better way is to increase the main grid current by reducing the value of the series resistance R_{SUB}, see Fig. 5, between main H.T.V. supply and main absorber grid, in other words by reducing the value of the sub-absorber anode resistance, since this is one and the same thing. It is in fact better to make the initial adjustments of the set such that the main absorber grid current is fairly high, for if so, it will be found that the valve emission will remain steady at the required value over a long period. Of course the sub-absorber anode feed will be increased in proportion but it should still be well within the safe limits of emission for the type of valve employed. For standard transmitters the value of R_{SUB} may safely be of the order of 55,000 ohms.

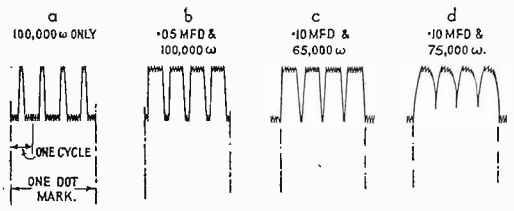


FIG. 7.

An interesting overall check on this adjustment is to note the No. 2 Magnifier anode current reading during the "space" period before and after an alteration in the main absorber grid current.

High Power Tone Modulation.

When the main supply to the transmitter is single phase A.C., the smoothing system in the main rectifier may be cut out, a process which restores the feed to simple full wave rectified A.C., that is, to a series of direct current impulses of twice the frequency of the supply and of approximate sine formation—the voltage rising to peak values that may vary from 1·2 to 1·5 times the voltage of the original smoothed current. With this form of supply the output of the transmitter obviously becomes effectively tone modulated, and in fact the method is the most satisfactory form of tone modulation, when a single phase supply is available. Mostly, however, the supply is 3 phase and for practical reasons one aims at designing the plant with the minimum amount of running machinery possible, a principle which precludes transforming from three phase to single phase simply for the sake of tone modulation. On the other hand where the station is self-contained with its own source of power, there is no reason why the individual transmitter supply units should not be single phase, and the following few notes may be of service.

In Fig. 8 the item (A) indicates a theoretical current or voltage curve for unsmoothed rectified A.C.; owing, however, to transformer induction the current is distorted from pure sine formation and does not fall to zero value, the result

being as indicated by item (B). Now this distortion introduces harmonics while the imperfect cut-off probably reduces modulation to a figure of about 80 per cent. If, however, the supply is shunted by a small value of capacity—*i.e.*, if a little of the original smoothing bank of condensers, say 0·2 mfds. in the case of the 20 kw. Standard Beam Transmitter, is left in—then the trough of the current or voltage supply is rounded off, as depicted at (C), and the higher harmonics are thereby

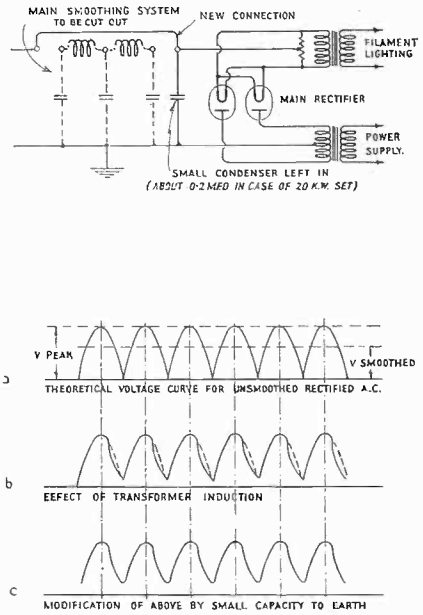


FIG. 8.

eliminated. It is true that the percentage modulation is further decreased, perhaps to 70 per cent., but, as already pointed out, this is a very desirable and important compromise when high speed working is aimed at ; in any case the gain at the receiver due to the narrowing of the wave band appears to be well within the paying limits of this compromise. Thus during a series of tests over some thousand of miles the difference between plain unsmoothed supply and unsmoothed supply modified by a shunt of 0·2 mfds. capacity gave average readings on the receiver heterodyne vernier condenser of 25 degrees and 15 degrees respectively, representing in this instance, perhaps, total widths of bands of 10,000 cycles and of 7,000 cycles. In the first case the series of reports, summarised, were as follows : " Signals strong but formation poor on slip at 200 w.p.m. Slip O.K. at 175 w.p.m.," while in the second case the reports might be summarised as : " Signals strong and steady. Good slip at 200 w.p.m."

Tone Frequency.

The single phase alternators should not be run above such a speed as gives 250 cycles, equivalent to 500 cycles when double rectified. In the case of sets designed to supply single phase A.C. to new stations, that is, where there is freedom of choice of machine periodicity, the latter should be specified not higher than 200 cycles, to give a note of 400 cycles.

Valve Saturation.

A fault to guard against when employing high power tone modulation is that the peak anode voltages may cause a momentary saturation of the main magnifier filaments, and to a lesser extent of the other magnifier filaments ; this may not be discernible on the instruments but will lead to " flat top " emission and consequent accentuation of the higher harmonics. For this reason it is preferable to run the valves at slightly higher voltages than are apparently necessary to avoid saturation.

Moving Coil Instruments.

It should be realised that moving coil meters are not reading correctly when the main supply is unsmoothed A.C. and that effective voltages and currents will be about 1·2 times apparent readings.

N. WELLS.

621.385.05

NOTES ON TRANSMISSION MEASUREMENTS

A brief survey of the development of the units used in transmission measurements up to the present day is given, together with formulæ and a table relating the various quantities.

The Marconi Transmission Measuring Set and its method of use are described and the questions of transmission levels and turnover are briefly discussed.

General Survey.

THE last few years have witnessed a great development in the methods of measurement and in the systems of units for use in determining the electrical transmission conditions existing in the medium of propagation and in the apparatus used for the transfer of intelligence from one place to another by electrical means.

Until about two years ago there were several systems of measurement in use, some of which were progressive improvements upon the earlier ones, which, however, had not been abandoned. In 1926 there was held in Paris the annual conference of the Comité Consultatif Internationale des Communications Téléphonique à Grande Distance, at which two new units, the Bel and the Néper were recommended as the basis of all future communications measurements.

It is interesting to note that these Units were named after Alexander Graham Bell the inventor of the telephone and Lord Napier the inventor of Logarithms.

The chief systems in use before the Conference were as follows :—

Mile of Standard Cable.
βl Unit.
British Standard Mile and
Transmission Unit.

The Transmission Unit and the βl Unit have been standardised as the Bel and the Néper, except that the Transmission Unit was raised to ten times its previous value, the original Transmission Unit becoming the Decibel or one-tenth of a Bel.

The popular abbreviation for Decibel is "db," although to the best of the Author's knowledge no official abbreviation was recorded at the Conference.

Explanation of Transmission Measuring Systems.

It should be clearly understood that all the units used for the measurement of transmission characteristics are relative. They differ greatly from the normal types of absolute measurement having a fundamental basis such as the centimetre, the gramme and the second.

The use of a ratio does not require any knowledge of absolute values, for instance, we may know that a weight A is four times as heavy as a weight B without knowing anything about the actual values of the weights. If an absolute measure of the power in a circuit is required it is now general to measure what is known as the "level" of the circuit at any given point. The question of "level" and its measurement is discussed further on.

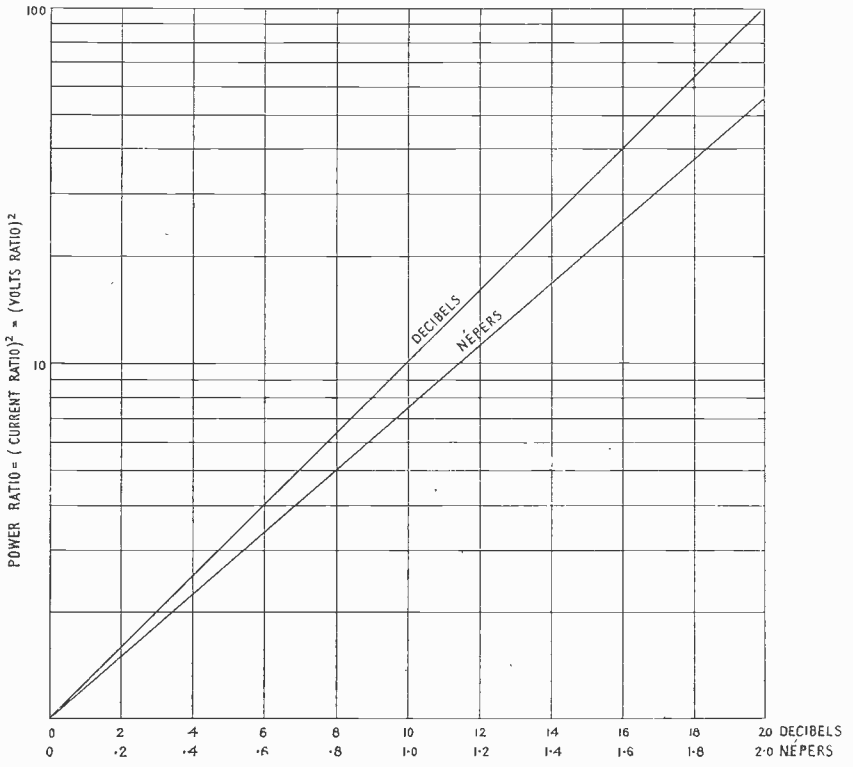

100
10
POWER RATIO = (CURRENT RATIO)² = (VOLTS RATIO)²
DECIBELS
NÉPERS
0 2 4 6 8 10 12 14 16 18 20 DECIBELS
0 ·2 ·4 ·6 ·8 1·0 1·2 1·4 1·6 1·8 2·0 NÉPERS

FIG. 1.

Some of the earlier attempts to measure transmission characteristics were carried out by comparing the cable to be measured with an arbitrary standard. This standard, known as the "Mile of Standard Cable," or M.S.C., was defined as being a cable having uniformly distributed resistance of 88 ohms per loop (go and return) mile, uniformly distributed capacity of 0·054 microfarads per mile and uniformly distributed inductance of 0·001 henrys per mile, while the shunt leakance was considered to be zero. American practice assumed the inductance to be zero as well as the leakance so that the English standard is approximately 3 per cent. higher than the American, that is to say that a cable measured in accordance with the American standard would appear to have an attenuation 3 per cent. higher than

if it were measured with the English standard. By comparing the output from the cable under test with that from a variable artificial line having the above characteristics, with equal input currents, the attenuation or transmission characteristic of the cable may be ascertained. The results are, of course, stated in the form of a ratio, viz., that of the electrical length of the cable tested, compared with that of the standard.

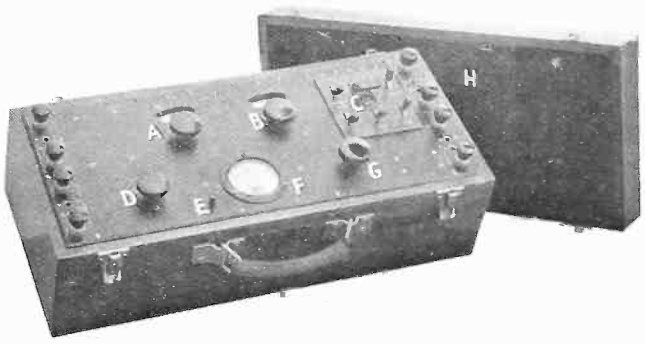


FIG. 2.

The formulæ connecting M.S.C. with current, voltage and power, are as given below:—

$$\text{M.S.C.} = 21{\cdot}12 \log_{10} \frac{I_1}{I_2}$$

$$21{\cdot}12 \log_{10} \frac{V_1}{V_2}$$

$$10{\cdot}56 \log_{10} \frac{P_1}{P_2}$$

where I_1 and I_2 = input and output current respectively.
V_1 and V_2 = input and output voltage respectively.
P_1 and P_2 = input and output power respectively.

It is, of course, essential that the currents be measured with the cable correctly terminated, unless allowance be made for any errors introduced by incorrect termination, since, although we may measure either the input and output currents or voltages, it is necessary to remember that we are actually interested in the transmission of power. A negative result in an attenuation formula should be taken to represent a gain instead of a loss.

All transmission measuring units are logarithmic in character as in the case of M.S.C., because the rate of decay of an impulse transmitted along a conductor follows a logarithmic or exponential law. For this reason, attenuation, which is a measure of the rate of decay, has also been measured in terms of natural logarithms;

thus the ratio of the input to the output current may be used to ascertain the attenuation by the following formula :—

$$\text{Attenuation} = \log_\epsilon \frac{I_1}{I_2}$$

The attenuation as given by all transmission formulæ is, in general, a complex quantity of the form $\beta + j\alpha$, since there is usually a progressive change of phase as the impulse proceeds along the cable.

In addition we may measure attenuation in terms of the voltage or power at the end of the cable as a ratio of that at the input, in which cases the formulæ are as follows :—

$$\text{Attenuation} = \log_\epsilon \frac{V_1}{V_2}$$

$$= \tfrac{1}{2} \log_\epsilon \frac{P_1}{P_2}$$

The unit in which the above values of attenuation are expressed is the βl unit where "β" represents the attenuation per unit length and "l" is the length of the line. This unit which is sometimes known as a "Hyp" has not been much used on account of its size, which is rather inconvenient, whereas the M.S.C. which is approximately one-tenth of the size of the βl Unit has had an extensive application, both in this country and in America.

Referring again to the M.S.C. unit, it will be appreciated that as direct comparison is made with a standard cable or with a sub-standard artificial line equal to the standard cable, which is reactive, the attenuation of the standard will vary with the frequency, and therefore an arbitrary testing frequency of 5,000 radians per second (796·4 cycles per second) has been generally adopted. The fact that this frequency is now not generally considered to be a representative point in the spectrum of voice frequencies, and that the attenuation of the standard depends upon the frequency, has brought about the use of other units of measurement.

The British Standard Mile, or B.S.M., is another unit which, however, was not destined to receive widespread recognition as it showed no great advance upon those already existing. The relationship between the B.S.M. and other units is shown in Table I.

A great advance was made with the introduction of the Transmission Unit, which, under another name, is in almost universal use to-day. The Transmission Unit has several advantages ; it is not dependent on frequency, it is of a very convenient size, it is based on common logarithms instead of on Naperian logarithms and the factor appearing in the formulæ is an integer which is easily remembered.

$$\text{T.U.} = 20 \log_{10} \frac{I_1}{I_2}$$
$$= 20 \log_{10} \frac{V_1}{V_2}$$
$$= 10 \log_{10} \frac{P_1}{P_2}$$

At the Conference of the C.C.I. in Paris, as mentioned before, the units were changed and named the Bel and the Néper, the following formulæ applying :—

$$\text{Bel} = 2 \log_{10} \frac{I_1}{I_2} \qquad \text{Néper} = \log_{\epsilon} \frac{I_1}{I_2}$$
$$= 2 \log_{10} \frac{V_1}{V_2} \qquad = \log_{\epsilon} \frac{V_1}{V_2}$$
$$= \log_{10} \frac{P_1}{P_2} \qquad = \tfrac{1}{2} \log_{\epsilon} \frac{P_1}{P_2}$$

The Decibel or " db " which is the tenth part of a Bel is now the unit most used and is exactly the same as the obsolete Transmission Unit.

TABLE I.

	Bel	Decibel	Néper	TU	βl	BSM	MSC
Bel ..	1·0	10·0	1.15	10·0	1·15	10·844	10·56
Decibel ..	0·10	1·0	0·115	1·0	0·115	1·0844	1·056
Néper ..	0·8686	8·686	1·0	8·686	1·0	9·42	9·175
TU	0·1	1·0	0·115	1·0	0·115	1·0844	1·056
βl	0·8686	8·686	1·0	8·686	1·0	9·42	9·175
BSM ..	0·0923	0·923	0·1062	0·923	0·1062	1·0	0·974
MSC ..	0·0947	0·947	0·109	0·947	0·109	1·0267	1·0

Multiply the units in the vertical column by the ratio shown to obtain the units in the horizontal line.

The multipliers giving the relations between MSC and the other units are based on the American standard cable having zero inductance and leakance. For the English cable (MSC) the values in the horizontal line should be reduced by 3 per cent. and those in the vertical column should be increased by 3 per cent. The unity figure is, of course, excepted.

Fig. 1 shows the value in Decibels and Népers of various values of power, current and voltage ratio.

Other Transmission Measurements.

There are two other transmission measurements which may be made with apparatus, the same or similar to that used for the measurement of transmission gains and losses. These are Level and Turnover measurements.

Level Measurement.

It will readily be appreciated that in any system conveying energy or matter, in which attenuation or loss occurs one may consider the system to experience a continuously decreasing power or quantity level as one proceeds from the input to the output end. Now, in an electrical transmission system there is continuous loss of energy and as a result of this there is a continuous drop in level.

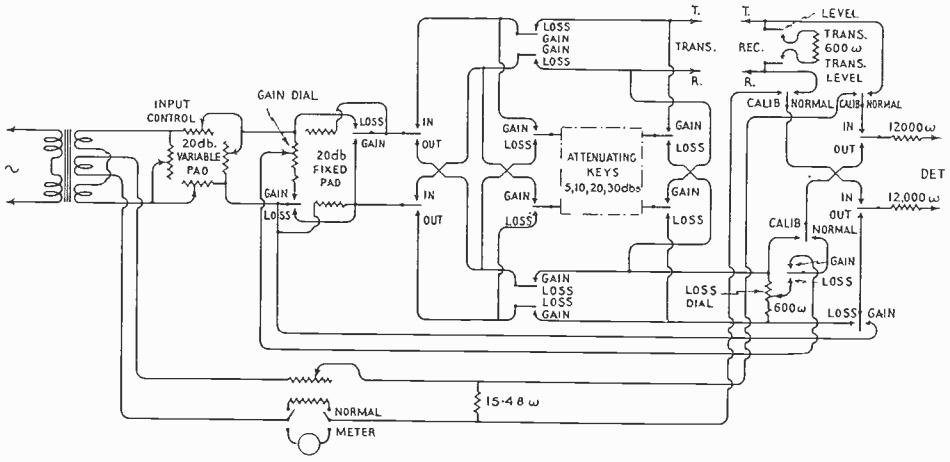


FIG. 3.

Obviously if we can measure level we shall have a very ready means of determining whether any part of our lines or apparatus are overloaded and whether a leakage or reflection of energy is taking place. Such a measurement also provides a ready guide for manual or automatic control of output at the point of junction of two trunk lines or between a trunk line and a radio system in order to compensate for changes in the length of the incoming trunks and for differences in speakers' voices and/or microphones. Such an arrangement enables a long distance circuit, including cables, repeaters, radio, etc., to be worked under the best operating conditions peculiar to each part, level adjustments being made at each junction.

In measuring any quantity, as distinct from a ratio, some point of reference is required, and level is measured with reference to an arbitrary point known as *zero level*.

Unfortunately there are several values of zero level used for different purposes, but probably the best is the zero level of one milliwatt. If the power passing a given point in a transmission system is one milliwatt the level is said to be *zero level*, and levels above and below zero are measured in Bels and Népers. It must be remembered that level is normally a power measurement and the formulæ are therefore :—

$$\text{Change of level} = 10 \log_{10} \frac{P_1}{P_2}$$

$$\text{Level} = 10 \log_{10} \frac{1}{W}$$

where W is the power in milliwatts at the point at which the level is being measured.

Of course level may be measured or spoken of as a voltage or current level, but in such a case the fact should be specified to avoid confusion. Since the above formulæ are derived from the attenuation formulæ, a positive result is a loss, and a negative result represents a gain, but when referring to level one speaks of a point which is higher by n db, as being at a level of $+ n$.

Turnover.

Turnover is lack of balance of the various parts of a line or apparatus to earth and is so called because it may be detected by reversing or turning over one end of a line and making transmission measurements in the two conditions.

An oscillator having an unbalanced output circuit will often suffer from turnover which causes one half cycle to differ from the other, thus producing the effect of a symmetry.

Perhaps the most serious trouble caused by lack of balance is the transfer of energy from one telephone line to another or to a telephone line from a neighbouring telegraph or power line. This is known as crosstalk and manifests itself in the form of unwanted speech or noise on the line. A clear division between the cause and the effect should be made. Both may be measured, the cause (unbalance) in micro-farads, henries and/or ohms according to its nature, or (turnover) in Bels or Népers, and the effect (crosstalk) may be measured in crosstalk units. 1 CTU exists when the energy transferred to another circuit is $1/10^6$ of the power in the exciting circuit, and the result of crosstalk which is noise, may be measured as a level, also in terms of Bels and Népers.

The Marconi Transmission Measuring Set.

A Transmission Measuring Set has been developed for the purpose of measuring the transmission characteristics of lines and apparatus having an impedance of 600 ohms, and has the following ranges.

The set will measure Gains from 0 to 70 decibels, Losses from 0 to 70 decibels, and Levels from −70 to +20 decibels.

Turnover measurements may also be carried out and these measurements are explained later on. It should be pointed out that the set can also be designed to measure lines or cables other than those of 600 ohms impedance, although the majority of cables have an impedance of the latter value. The error caused by using a 600 ohms set to measure cables of impedances other than 600 ohms is discussed later.

Fig. 2 is a photograph of the Transmission Measuring Set, which consists of the following visible parts :—

A. Loss Dial.
B. Gain Dial.
C. Keyboard.
D. Input Control.
E. Meter Key.
F. Meter.
G. Calibration Control.
H. Compartment for plugs and cords.

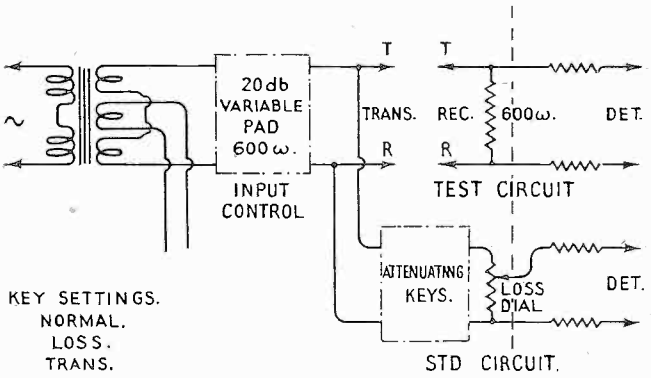


FIG. 4.

The following keys are provided on the keyboard, reading from left to right :—

Top Row.

1. The Normal-Calibrate key which is used to bring the measuring or the calibrating circuits into use.

2. The Gain-Loss keys which are operated together by means of a bridged handle and which converts the circuit from the Gain to the Loss measuring condition.

3. The Transmission-Level key which changes the circuit to provide for the measurement of transmission gains or losses and levels.

Bottom Row.

1. The 5 and 30 Decibel key for inserting an attenuating pad of either 5 or 30 Decibels into the standard circuit.

2. The 20 and 10 Decibel key for inserting an attenuating pad of either 20 or 10 Decibels into the standard circuit.

3. The In-Out key for comparing the circuit under test with the standard. The key is marked IN-OUT because the instrument virtually measures the ratio of input to output, the two tones being equalised for balance in the detector circuit by the insertion of the variable standard loss.

Inside the instrument is mounted an input transformer, various attenuating pads, and potentiometers and resistances.

The schematic diagram is shown in Fig. 3, from which it can be seen that the method of measurement adopted is one of comparison with standards included within the instrument. The question of difference in phase between the output potential of the circuit under test and that of the standard is one which may be neglected since the outputs are connected alternatively to the detecting device, which may be either a telephone receiver or a valve voltmeter. Since in either case only one potential is applied at a time it is necessary only to compare the RMS voltages produced without reference to any change of phase.

Referring to the circuit diagram, and reading from left to right, the input transformer which has an input impedance of 600 ohms feeds energy into the measuring circuit and/or the calibrating circuit. The measuring circuit will now be considered.

This circuit includes a variable 20 db pad, known as the input control, which enables the energy in the test and standard circuits to be altered without changing the energy level in the calibration circuit, since its input and output impedance are constant, only the attenuation being variable.

The next item is a fixed 20 db pad, of which the Gain Dial forms a part, which is only used for gain or positive level measurements. Here the circuit splits and the energy passes (A) to the " TRANS." terminals and so to the test circuit, and

(B) to the Loss Dial or standard circuit.

The two attenuating keys will be in the (A) path when measuring gain and in the (B) path when measuring loss.

From the test circuit the energy passes through the " REC." terminals to the detector and from the loss dial also to the detector. The detector circuit, consisting of two high resistances and either a Bell receiver or a valve voltmeter, is connected to only one of the (A) and (B) circuits at one time. The total impedance of the detector circuit is not less than 24,000 ohms and therefore the effect produced by its presence is entirely negligible.

The forgoing remarks should make clear the fact that the test and standard circuits receive the same input and therefore that if the output balances the loss or gain in each side must be equivalent.

When measuring loss, a loss in the test circuit is balanced by a known added loss in the standard circuit, and when measuring gain, a gain in the test circuit is balanced by a known added gain in the standard circuit and, if necessary, by a known added loss in the test side as well.

The calibrating circuit is discussed under the heading " Calibration."

It will be noticed that there are two main circuit conditions, viz., those for measuring loss and gain.

Loss Measurements.

It will be seen from Fig. 4 that, with the aid of the " IN-OUT " key, the input voltage is applied to the circuit under test and to the standard, the detector circuit, shown to the right of the vertical line, being transferred to the output of each circuit in turn. The keys should be set as follows for making loss measurements :—

" Calib-Normal " key to " Normal."
" Gain-Loss " key to " Loss."
" Trans-Level " key to " Trans."

If, now, with the circuit to be tested connected as shown in Fig. 5, the " IN-OUT" key is operated from one position to the other a change in volume will be heard in the receiver or a change in deflection will be noticed on the valve voltmeter. The loss dial which reads from 0 to 20 Decibels in steps of 0·5 db., and, if necessary, one or both of the attenuating keys should be adjusted until a balance is obtained with the key in the " IN " and " OUT " positions.

The loss inserted between the transmitting and receiving terminals is then equal to the sum of the losses indicated on the loss dial and the attenuating keys.

For reasons which will be explained under " Turnover," the " tip " and " ring " terminals should be joined respectively together through the line or apparatus under test, that is to say, tip should be joined to tip and ring to ring. Fig. 5 shows the correct and the incorrect methods of joining the circuit to be tested to the terminals of the set. If it is not possible to verify this, a further test should be made with the leads at one end reversed and the mean of the readings should be taken.

The input level when measuring loss with the set correctly calibrated is zero level.

Gain Measurements.

The circuit arrangement for gain measurements is shown in Fig. 6 from which it is obvious that the input energy after passing the input control pad is first attenuated by 20 db in the fixed pad and that further attenuation may be added by means of the attenuating keys, if required, before it passes to the input of the circuit under test. The keys should be set as follows :—

" Calib-Normal " key to " Normal."
" Gain-Loss " key to " Gain."
" Trans-Level " key to " Trans."

The " IN-OUT " key when in the " IN " position enables the output from the " test " circuit to be ascertained. When the key is thrown to the " OUT " position

the detector is connected across the gain dial, which forms part of the 20 db fixed pad, in order to measure the input, attenuation being added to balance the tones in the receiver by adjustment of the dial. When the dial is all included in the circuit, that is to say when the slider is at the top in Fig. 6, the energy level at the input to the standard circuit is 20 db higher than at the input to the test circuit so that, provided the gain tc be measured is not more than 20 db it may be measured on the gain dial. If the gain exceeds 20 db the attenuating keys must be used. These insert pads immediately before the test circuit, thus cutting down the input level as well as assisting in the measurement. This is an advantage as it prevents the output level from rising above zero level and possibly overloading the amplifiers or repeaters in the test circuit which, by causing distortion, would produce inaccurate gain readings. It is apparent that by varying the position of the slider on the potentiometer forming the gain dial, and by adjustment of the attenuator keys, the ratio of input potential to output potential of the standard circuit is varied and may be adjusted until it is equal in the two positions of the " IN-OUT " key, in which case the gain is equal to the sum of the gain dial and attenuating key readings.

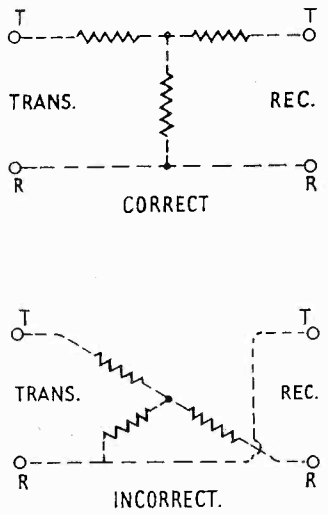


FIG. 5.

The input level when measuring gain with the set correctly adjusted is —(20 db + the sum of the attenuating key settings).

Calibration.

Calibration is only necessary when tests are to be made with a definite input current or input level. The normal level for making transmission measurements is " Zero level." The value of zero level has several definitions and as many values, which are used for different types of measurements or for measurements on different apparatus as has been explained. The value of zero level commonly used for measurements on lines and cables for voice frequency telephony is one milliwatt, *i.e.*, when a power of one milliwatt is being fed to a line it is said to be working with an input of zero level.

It is necessary during calibration so to adjust the apparatus that the input current to the circuit under test is at a level of one milliwatt or zero level. To enable this to be done, an additional winding, the tertiary, is provided on the transformer, together with a meter and key and several fixed and variable resistances. The meter key is arranged to insert the meter in circuit in place of the protective

resistance of equal value which replaces the meter when the latter is not required, and which can be used to switch off the meter quickly in the event of the current rising too rapidly. The meter is, however, of a fairly robust nature. To calibrate the set the keys must be set as follows :—

" Calib-Normal " key to " Calib."
" Gain-Loss " key to " Loss."
" Trans-Level " key to " Trans."

Then with both the attenuating keys in their zero positions the meter key is pulled and the calibration adjustment knob is rotated to adjust the meter reading to 50 m.a. in which condition the potential drop across the 15·48 ohm resistance (shown in Fig. 7) is the same as that across the input end of a 600 ohm line having an input of zero level.

Now, if the " IN-OUT " key be thrown backwards and forwards, a difference in volume will be heard in the receiver. This difference should be equalised by adjustment of the input control knob, *i.e.*, the 20 db variable pad, which controls the amount of energy passing to line. When a balance has been obtained the circuit is correctly calibrated and the input and calibration controls should not be altered. The meter should be watched to see that the current remains at 50 m.a. It is, of course, necessary to recalibrate the set when the frequency is changed.

Calibration at Levels other than Zero Level.

If it is desired to operate the set at levels other than zero level the current in the calibration circuit may be set to a predetermined value other than 50 m.a.

The formula is given below :—

$$\text{Meter reading} = 50 \sqrt{\text{Level.}}$$

The meter reading is to be expressed in *milliamperes* and the level required in *milliwatts*. Thus a level of 2·25 milliwatts is the highest which can be used with the existing meter having a maximum reading of 75 milliamperes.

For gain measurements a higher input level may be obtained, if required, by the simple expedient of calibrating the set with the attenuating keys adjusted to the required number of decibels and then re-setting the keys to the zero position before making measurements. In this case the input level will be —(20 db—the sum of the attenuating key readings as set during calibration) and the meter should, of course, be adjusted to 50 milliamperes in the ordinary manner. If the attenuating keys are changed from the zero position during measurement the formula for the level is —(20 db—calibration setting of keys + measuring setting of keys).

In this connection a table of levels showing the relation between decibels and milliwatts will be found useful. (See Table II.)

The Measurement of Apparatus having Impedances other than 600 ohms.

The set may be used to measure apparatus having impedances other than 600 ohms and the errors will not in general be great.

TABLE II.

INPUT LEVEL.

Decibels.	Milliwatts.
0	1·0
1	1·259
2	1·585
3	1·995
4	2·512
5	3·162
10	10·0
15	31·623
20	100·0

Alternatively, two transformers having an impedance of 600 ohms for one winding and the other of the impedance of the apparatus to be measured may be inserted between the TRANS.-REC. terminals with the new value impedance windings joined, and the loss measured. Then the apparatus to be measured is inserted between the transformers and the total loss is measured. The loss in the apparatus is the total loss minus the loss in the transformers. It should be understood that where the impedance is not 600 ohms, the input level will be altered.

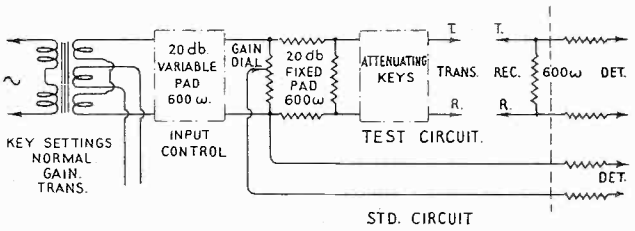


FIG. 6.

Measurement of Level.

Level measurement differs from other measurements in that only the point of the line at which the level is required is connected to the set.

The point to be tested is connected to the REC. terminals and the circuit is tested in the ordinary manner, the level being read from the Loss Dial and attenuating keys. The circuit conditions are exactly as for making transmission measurements save that the 600 ohms terminating resistance across the REC. terminals is removed. The keys should be set as follows :—

" Calibrate Normal " key to Normal.
" Gain Loss " key to Loss.
" Trans-Level " key to Level.

Positive levels are measured by calibrating to, say, 20 db above zero level and measuring on the loss dial. The calibration is carried out by setting the attenuating keys to 20, and adjusting for balance. The measurement is then made with the attenuating keys returned to normal. The level, being measured, then equals (20 — setting on dial — setting on attenuator keys).

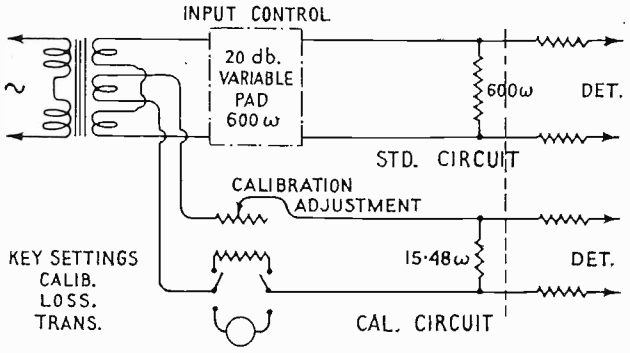


FIG. 7.

It will be noticed that the attenuating keys have no effect when measuring positive levels.

Method of Checking the Accuracy of the Transmission Measuring Set.

The set may be checked at any time by joining the TRANS. and REC. terminals together when upon making measurements Zero Gain and Zero Loss readings should be obtained.

To check the attenuating keys and the other parts of the dial scales the terminals should be joined through known attenuating pads and measurements made. Values for a few square π pads are given in Table III.

TABLE III.

Decibels.	Series Arms.	Shunt Arms.
5	182·3 ohms	2143·0 ohms
10	428·45 ,,	1156·0 ,,
20	1483·0 ,,	733·5 ,,
30	4739·5 ,,	639·3 ,,

Should there not be sufficient resistance available to form pads, a check may be made with a single resistance box which should be connected in shunt with the TRANS. terminals.

Appropriate values of resistance are given in Table IV.

TABLE IV.

Decibels.	Resistance.
1	2400 ohms
2	1120 ,,
3	720 ,,
4	510 ,,
5	390 ,,
10	140 ,,
20	33 ,,

O. S. PUCKLE.

MARCONI NEWS AND NOTES

MARCHESE MARCONI ELECTED PRESIDENT OF ITALIAN ROYAL ACADEMY

THE many friends of Marchese Marconi, in all parts of the world, will be gratified to learn that he has received a further honour from the King and people of Italy in being appointed a member and President of the Italian Royal Academy.

This appointment followed a special vote taken at a meeting of the Academy on September 19th, in accordance with which Signor Mussolini submitted two decrees to the King of Italy, one appointing Marchese Marconi a member of the Academy, and the other conferring upon him the Presidency, in succession to Signor Tittoni, who has resigned on account of ill-health. These decrees were immediately approved by the King, and published.

Marchese Marconi has been a Senatore of Italy since 1914, and received the title of Marchese in June, 1929. He holds a number of other Italian honours and decorations, and amongst the honours conferred upon him by other countries is an honorary British Knighthood by the award of the Grand Cross of the Victorian Order in July, 1914.

World Power Conference, 1930.

Engineers from all over the world assembled at the second World Power Conference, held in Berlin this year.

A special feature of the Conference was a series of addresses by distant speakers, the addresses being simultaneously conveyed to Berlin and to the National Electric Light Association Convention in San Francisco. Marchese Marconi spoke from London. Lord Derby also spoke from England. Thomas A. Edison, Owen D. Young and Mathew Sloan spoke from the United States; and Dr. Carl Koettgen and Dr. Oskar Von Miller from Germany.

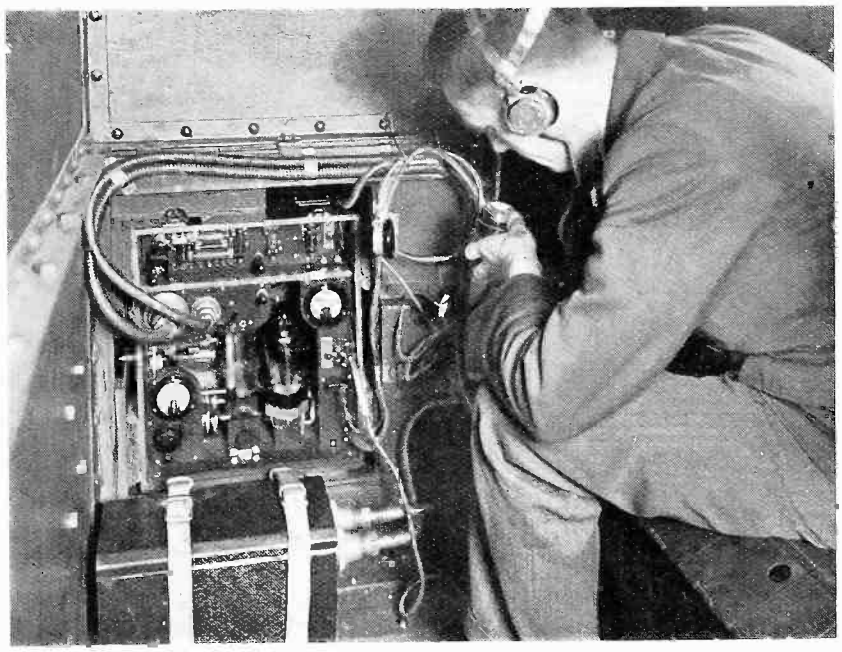
In the course of his address, Marchese Marconi referred to the participation of distinguished speakers in various separate and distant parts of the earth in the two conferences, and said: "This participation has been made possible by the great advances in radio and telephonic communication which have now come into active being, and which have already linked up the world in a way which was never experienced before."

Chairman's Letter to Marchese Marconi.

As a sequel, the following letter was sent by the Chairman of the World Power Conference to Marchese Marconi:

" It is our privilege and great pleasure, in the name of the German Committee for the Second World Power Conference, most warmly to thank you for kindly co-operating in the tele-communication effected on June 18th at the occasion of the World Power Festival. The fact that you, to whom humanity owes the great blessing of radio-telegraphy, participated in person in this memorable radio-phonic conversation, fully enhanced its historic significance, and greatly added to the thrill of the occasion. The acoustic reception of all speeches of this five-cornered radio conversation was quite perfect. Among the four thousand listeners in the banqueting hall, our Italian friends certainly had the greatest right to be proud of their compatriot, but it is true that all the prominent engineers, representing fifty nations, when hearing your voice, whole-heartedly united in the feeling of vocational pride in the great feat which was made possible through your genius.

" By your kindness you have greatly contributed towards the success of the Second World Power Conference. For this we would cordially thank you. We feel, however, that our thanks can but be a small expression of what the world owes you for alleviating its troubles and opening up a new era of international understanding and amity."



Special Marconi equipment installed in a Vickers-Armstrongs' Tank.

Wireless for Mechanised Armies.

The difficult problem of communicating over short distances from tanks and other armoured fighting vehicles has been satisfactorily met by Marconi's Wireless Telegraph Company, Ltd., who have developed for this purpose a special wireless set known as the Type S.B.1a.

It is an ultra short-wave portable installation—operating on between 7 and 8 metres—designed for wireless telephony and telegraphy to be used either as a permanent fitting in armoured vehicles or as a portable set for trench and other advanced military positions to which it can easily be carried.

The aerial is almost invisible and consists of a copper plated steel rod twelve feet in height and made in four sections. In use it is liable to be subjected to severe swaying and bending, but it is designed to be very flexible and will not buckle.

A feeder cable connects the transmitter to the aerial system which is connected to the body of the tank or to " earth " through a balancing coil so as to permit the maximum amount of energy to be transferred to the aerial for the wavelength in use.

Protection from Shocks.

The transmitter and receiver are compactly fitted in a teak instrument case and are very simple and easy to operate. When the set is fitted in a moving vehicle where jars and shocks would cause damage, these vibrations are eliminated by shock-absorbing slabs of sponge rubber.

Power for the transmitting valves is supplied by a rotary transformer, driven by a 12-volt accumulator, and delivering 600 volts to the anodes.

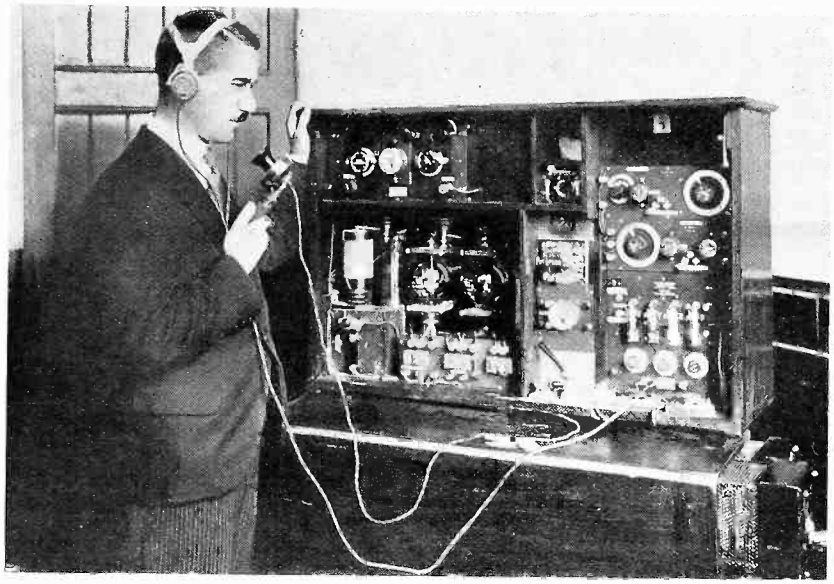
For telephony the choke control system of modulation is used, and for telegraphy an interrupter disc mounted on the shaft of the rotary transformer enables the tonic train system of transmission to be employed. Four valves are used in the transmitter, two oscillators and two modulators, and four valves are used in the receiver, the last two stages being note magnifiers.

Dual Control and Intercommunication.

An interesting innovation for land vehicles is the system of intercommunication and dual control which was previously confined to aircraft apparatus. This allows the wireless apparatus to be switched off and two people in the vehicle to communicate with each other by means of the telephones, or, alternatively, either of them can operate the wireless equipment. When communicating with each other the last two stages of the receiver are brought into use as speech amplifiers.

Wireless Telephony for Ships' Trials.

An important feature of the recent trial trip of the new White Star Liner " Britannic " was the use of Marconi wireless telephone sets fitted on board and in



Speaking by Marconi Wireless Telephone from Messrs. Harland and Wolff's offices at Belfast to the M. V. " Britannic " on trial in the Clyde.

the builders' offices to enable the observers and engineers at sea and ashore to keep in constant communication.

This was the first time that the wireless telephone was used in connection with a ship's trials, and the innovation proved of such value in exchanging reports of the performance of the new ship that as soon as the trip was completed Messrs. Harland and Wolff, the Builders, applied to the Post Office for permission for similar facilities for the " Innisfallen," which they had just constructed for the City of Cork Steam Packet Company. Sanction was given, and the utility of the Marconi telephone was again so marked that the installation of this equipment may become an important factor in ships' trials in the future.

The trials of the " Britannic " and the " Innisfallen " were held in the Clyde estuary, at a distance up to 150 miles from the builders' yards, and immediate communication was maintained throughout the trips, thus effecting a very valuable saving of time and expense in many particulars.

The telephone equipment fitted on these vessels and at Messrs. Harland and Wolff's offices at Belfast was installed by the Marconi Company, and is known as the Marconi Type Y.C.4. It is a combined transmitter and receiver instrument, the former having a power of 500 watts.